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Stock splits, a Survey

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Abstract

In this survey paper I summarize the literature's findings on the short-run and long-run effects of stock split announcements as well as what happens in the preceding and subsequent years around a stock split event. I also summarize how firm characteristics influence these results. Furthermore, I discuss the various theories regarding why splits occur and why stock return distributions change subsequent to split events. I specifically focus on the changes in the first and second moments of stock returns and analyze related theories such as optimal trading, optimal tick size, liquidity, and signaling. More importantly I present the pros and cons of each of these theories and discuss which of them are more plausible. I suggest that a combination of the several theories suggested in the literature can rationally explain the return distribution changes around stock splits. I conclude with suggestions for future research.

JEL Classifications: G00, G10, G30

Keywords: Stock split, stock splits, split ex-date, split announcement, optimal tick size, clientele changes, survey on stock splits

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Introduction and Motivation for the Review:

In an efficient market, the market value of a firm's equity should be independent of the number of shares it has outstanding. Therefore one should expect to see no change in the distribution of stock returns around ex-dates of stock splits. Yet, Grinblatt, Masulis, and Titman (1984), Lakonishok and Vermaelen (1986), and Lamoureux and Poon (1987) document short-term abnormal returns around announcement days and ex-dates of splits. Recently Ikenberry, Rankine, and Stice (1996) and Desai and Jain (1997) have verified the earlier findings regarding short-term excess returns following stock splits and furthermore Ikenberry, Rankine, and Stice (1996), Desai and Jain (1997) and Byun and Rozeff (2003) have also documented long-term excess returns in the three years subsequent to split events for the 1975-1990 time period. In addition to changes in the distribution of stock returns around ex-dates of stock splits, Ohlson and Penman (1984), Dravid (1987), Dubofsky (1991) and Koski (1998) show that stock return volatilities jump significantly after stock splits as well and that these volatility changes hold for more than a year subsequent to the split ex date. In their recent paper Julio and Deng (2006) document that the return volatility jump that is expected to occur on the split ex date of a stock is preceded by a change in the implied volatility of the stock's option around the split announcement date. They show that this change in the implied volatility varies positively with the size of the actual change in the return volatility of the underlying stock, validating that the stock return volatility jump on the split ex-date is real and that it is not merely a measurement error.

While these facts stand, there is no convincing theory that affirmatively explains why companies continue to split their stocks, and furthermore the cause of the increase in stock return volatility following the split ex-date remains uncertain. Therefore, this paper is organized in five sections as follows: In Section 1, I will present the empirical results that establish return anomalies around split announcements and split ex-dates. In doing so I will explicitly describe each methodology undertaken in these empirical studies. In Section 2, I will present the empirical results that document volatility jumps around split ex-dates and again I will explain the measurement techniques carefully. In Section 3, I will describe the theories that explain why stock splits happen. In Section 4, I will describe the theories that have been put forward as

possible explanations of stock return volatility increases subsequent to splits. In Section 5, I will describe a hypothesis that can consistently explain both why splits occur and why subsequently stock return volatility increases.

Section 1: Stock Returns Before and After Announcements and Ex-dates of Stock Splits

1.1 Long Term Excess Returns Preceding Split Announcements:

The first empirical study on stock splits was done by Fama, Fisher, Jensen and Roll in 1969. In this paper Fama et al. (1969) examine 940 stock splits over the period 1927–1959. Using a market model and monthly returns they find on average an abnormal excess return of 34.07% over the 29 months preceding the split date for splitting companies. Fama et al. find no abnormal returns after the ex-split date. Lakonishok and Lev (1987) expand on the Fama et al. (1969) paper and define split events around announcement dates using a sample size of 1015 in the time frame from 1963 to 1982. They also find significant abnormal returns for splitting firms preceding the splits (on average they find 53% excess returns in aggregate during the 5 years preceding the split announcement). Further validating these studies Asquith et al. (1989) find statistically significant market adjusted excess returns of 56.8% for splitting firms for the 240 day time period preceding a split in the 1970-1980 time period. McNichols and Dravid (1990), and Maloney and Mulherin (1992) also find similar results and these numbers are also confirmed by later studies such as Ikenberry, Rankine, and Stice (1996) and Desai and Jain (1997) for different time-periods. These studies confirm without a doubt that split events are preceded by very strong performances for the splitting companies as they compare to non-splitting firms.

1.2 Short Term Excess Returns Subsequent to Split Announcements and Ex-Splits Days:

Other researchers find excess abnormal returns around split announcements and ex-split days using an event-study approach. Grinblatt, Masulis, and Titman (1984) show that stock split announcements are associated with excess positive returns following the announcement. The authors use a mean-adjusted returns methodology, developed by Masulis (1980), in order to measure the excess returns. Where the event date is numbered 0 following Fama et al. (1969) convention, for days 4-43 subsequent to the event GMT (1984) construct a time-series. They

assume that the return process is stationary and that this time series is representative of the stock return distribution for that specific equity. The mean of this time-series is used as a representation of the typical returns around the event and the return series is mean-adjusted using this value. Using this methodology GMT (1984) analyze 244 pure split events where there are no other corporate events in the window studied. They form so-called event-time portfolios where corresponding daily returns of split-events are averaged to determine a portfolio return over time around splits. They find that the average returns for a splitting stock are 1.96% and 1.33% respectively for the day of the announcement and for the day subsequent to the announcement day and that these values are statistically significant. Furthermore GMT (1984) also document post-announcement abnormal returns around the ex-dates of splits. These excess returns are 0.69% for the day of the split and 0.52% for the day subsequent to the split day, respectively, and also are statistically significant. Lamourex and Poon (1987) use a different event-time methodology. They first run a typical market model regression in a “neutral time frame” that should not be affected by new information arrival, in this case much before the news of a split. They take the daily returns of each of the splitting securities for days -250 to -130. Using the CRSP equally weighted index to proxy for market returns they run an OLS to estimate alpha and beta for each stock in this neutral time period:

$$R_{it} = \alpha_i + \beta_i * R_{mt} + \epsilon_{it}, t = -250, \dots, -130 \quad (1)$$

($\epsilon_{it} \rightarrow \text{iid}, N(0, \sigma^2)$, and ϵ_{it} is independent of R_{mt})

Using the estimators from their regression, in conjunction with the market returns for their period of interest (around announcement or ex-day), they calculate the expected returns for each stock for the event days studied. Using observed returns for each security for the event days studied they calculate the abnormal return for each security and then similar to GMT (1984) they construct a portfolio in order to determine the influence of stock splits on stock returns for the overall sample. To conduct t-tests on the portfolio they use a portfolio error variance that is calculated using the returns from days -120 to -60. Lamourex and Poon find a statistically

significant average excess return of 0.56% on the split ex-date. Lakonishok and Vermaelen (1986) also use a market model and find statistically significant excess returns in days - 5 through + 2 with an ex-date excess return mean of 0.74%. More recent studies such as the one conducted by Ikenberry, Rankine, and Stice (1996) (IRS) also find market adjusted abnormal returns of about 3.38% around split announcements. IRS (1996) report, however, that this abnormal return effect following the split has monotonically decreased in magnitude for all the sub 5-year time periods starting in 1975-1980 and ending in 1985-1990 (4.26% in 1975-1980, 2.02% in 1985-1990). IRS (1996) divide their sample into 10 size deciles and 5 B/M quintiles. They also calculate price percentiles for the adjusted post split price. In order to do this they divide the pre-split price of each splitting firm by the split factor³ plus one to find what each security's price would have been with the split factor³ plus one many outstanding shares. In their study they specifically look at 2-for-1 splits. Then, they compare the resulting price with all public firms in their size decile. Furthermore they use time-period dummies to capture the effects of the specific period the split event occurs in. Using the abnormal returns for the (-2,+2) period around the split, they run a cross-sectional multi-variate regression of the following form:

$$AR_{-2,+2} = \alpha_i + \beta_1 * SizeDecile_i + \beta_2 * B/M-Quintile_i + \beta_3 * PricePercentile_i + \beta_4 * d_{i,75-80} + \beta_5 * d_{i,80-85} + \epsilon_{it} \quad (2)$$

IRS (1996) report that in the short run, the five day period surrounding the split, market reaction to split announcement is negatively related to size, post-split price, and book-to-market ratio for 2-for-1 splits. These studies confirm without a doubt that splitting companies have abnormal returns on split announcement and split-ex days as well as on days immediately subsequent to these days. It is also clear that, at least in the short-run glamour stocks (low B/M value) are getting a bigger boost from split announcements than value stocks, while smaller stocks also benefit more from split announcements in the immediate aftermath of the announcement in the 1975-1990 time period. Further strengthening these results Woolridge and Chambers (1983), Lamoureux and Poon (1987), and Peterson and Peterson (1992) also study the market reaction

following reverse splits² in the short term and document negative returns in line with the positive excess returns that follow forward-splits (for example Woolridge and Chambers (1983) report a -7% return in the immediate days surrounding reverse splits).

1.3 Long Term Excess Returns Subsequent to Split Announcements and Ex-Splits Days:

There is a strong contradiction between earlier and later empirical findings regarding whether there exist long-term abnormal returns for splitting companies in the post-split period. Fama et al. (1969) analyze the time period from 1927 to 1959. Employing a market model and using monthly log returns they report no abnormal long-term returns following the split ex-date. Lakonishok and Lev (1987) focus on the 1963 to 1982 time period. They compare the long term stock prices of splitting firms versus a similar non-splitting control group in the post ex-split period. Lakonishok and Lev (1987) report that in the long run the two groups have nearly identical stock prices and conclude that there are no long term excess returns subsequent to ex-split dates. Practically, after the Fama et al. (1969) paper there is no paper in the literature that looks at the long term abnormal returns following splits until Ikenberry, Rankine, and Stice (1996) (IRS). IRS (1996) focus on the 1975 to 1990 time period and consider only 2-for-1 splits. IRS (1996) analyze 1275 pure split events in this time period that occur on NYSE/AMEX. They accumulate returns from the month of the split, by forming an equal-weighted buy-and-hold portfolio for a period of three years. At the end of each year the portfolio is rebalanced among surviving splitting firms. Furthermore in order to calculate the excess returns of this split-portfolio the authors create a matching portfolio. In order to do this they follow the convention in the empirical asset pricing literature and sort all the available NYSE/AMEX firms into 10 size deciles and further they sort each size decile into 5 book/market quintiles. In the month prior to a split each firm in the original split-portfolio is matched with a size/book-to-market portfolio. A reference portfolio is formed using the matched size/book-to-market portfolios on an equally weighted basis. As a firm is dropped from the original split-portfolio so is the matching

² Reverse Split: A reverse split occurs when a company reduces the number of its shares outstanding by a pre-determined value. For example, if a firm has 100 shares outstanding pre reverse-split and its reverse-split factor is 1-for-1 then the total number of shares outstanding post-event is 50. ($100 / (1+1) = 50$)

size/book-to-market portfolio dropped from the reference portfolio (of matched size/book-to-market portfolios) and the reference portfolio is rebalanced in a similar fashion to the original split-portfolio. Excess return is the difference in the return of the splitting-firms-portfolio and the concurrent mean return to the matched size and book-to-market portfolios (the return of the portfolio of matched portfolios). IRS (1996) use bootstrapping in order to measure the statistical significance of these excess returns. In order to do this, prior to a split, they randomly select a firm from the overall sample that matches the size decile and book to market quintile of the splitting firm. They repeat this for each splitting firm and form a random portfolio that emulates the original splitting-firms-portfolio. Then they compare the excess return of this emulation portfolio to that of the concurrent mean return of the matched size and book-to-market portfolios. They repeat this procedure 5,000 times and end up with an empirical distribution of excess returns. This empirical distribution is then used to assess the statistical significance of the excess return calculated from the first step where the original splitting-firms-portfolio is compared to the mean return of the matched size and book-to-market portfolios. The authors find that in the 1st year following the split announcement, splitting firms have an average return of 19.11% vs. 11.18% for non-splitting firms. The 7.93% difference is statistically significant as the p-value of this difference, calculated from the simulated excess returns distribution, is 0.000 implying that none of the bootstrap portfolios produces excess returns of this magnitude. IRS (1996) repeat this methodology for the following two years and they find that splitting firms outperform non-splitting firms by a statistically significant 12.15% in the three-year period subsequent to the split (for the overall 1975-1990 sample). Using this methodology IRS (1996) find significant excess long-term returns subsequent to stock splits in all the 5-year sub time periods they study. IRS (1996) also find that the aggregate excess returns measured from the time of the announcement until the end of the first year subsequent to the announcement are between 12% and 14%. They also report that for the smallest size deciles, size decile 1 through size decile 4, 60% of this aggregate excess return is realized in the few days following the split announcement. IRS (1996) also look at the post split performance of splitting companies depending on the price they reach subsequent to the split. They find that stocks that fall to the smallest price percentiles (1-10%) have positive returns in the 5 day window around the split announcement but that these

companies have average returns of -4.83% for the three year subsequent to the split. IRS (1996) also check for effects of momentum around the split. They group splitting companies into 10 groups based on their pre-split performance from the lowest pre-split run-up to the highest pre-split run-up. They find no effect of momentum in the 1975-1990 period and in fact some reverse momentum effect is observed in this time frame as the decile with the highest (lowest) pre-split run-up returns has the lowest (highest) post-split excess returns. Desai and Jain (1997) analyze a very similar time period (1976 to 1991) to that of IRS' (1996). They analyze all splits with split factors larger than 25%³. Furthermore, in addition to NYSE and AMEX they include NASDAQ firms in their sample and they also study reverse splits. Desai and Jain (1997) follow a methodology very similar to that of IRS' (1996). However, they divide the overall sample into 150 sub portfolios rather than 50 size/book-to-market portfolios by further sorting each size/book-to-market portfolio into 3 momentum groups based on raw returns in the 6 months preceding the split announcement. They follow a similar technique to that of IRS (1996) and match each splitting company to a size/book-to-market/momentum portfolio. Also similar to IRS (1996) they test for the statistical significance of excess returns via bootstrapping. Their results, not surprisingly, are very close to IRS (1996) as well. They find that in the 1st year following the split announcement month splitting firms have a statistically significant excess return of 7.05% (11.87% for the 3 years following the announcement on a Buy and Hold basis). Qualitatively and quantitatively these results confirm IRS (1996). Desai and Jain (1997) contribute to the literature by showing that reverse-splits also have long-term consequences as they result in negative returns in the 3-year period subsequent to the reverse-split announcement in the 1975-1990 time period. They find that reverse-split announcement month abnormal returns are -4.59% and that the abnormal returns in the 1st year following reverse-splits are -10.76% (-33.90% for the 3 years following the announcement on a Buy and Hold basis). Perhaps the most complete account of long-run performance of stock-splits is given by Byun and Rozeff (2003). Byun and Rozeff (2003) show that Fama et al. (1969) and IRS (1996) and Desai and Jain (1997) are all correct as their extensive study proves that post split long-run

³ Split Ratio: If split ratio is $x\%$ and the number of total outstanding shares before the split is N , then the number of total outstanding shares post-split is $(1+x\%)*N$

performance is greatly affected by the time period studied. Byun and Rozeff (2003) analyze 12,747 stock splits from 1927 to 1996 using two methodologies. In the first methodology, they form size/book-to-market portfolios similar to IRS (1996) and Desai and Jain (1997). Byun and Rozeff (2003) measure excess returns starting from the split ex-date, unlike IRS (1996) and Desai and Jain (1997) who measure excess returns from split-announcement date. For the overall sample they find significant excess returns for a specific group of splits: 2-for-1 splits. For such splits Byun and Rozeff (2003) report an average excess return of 3.74% in

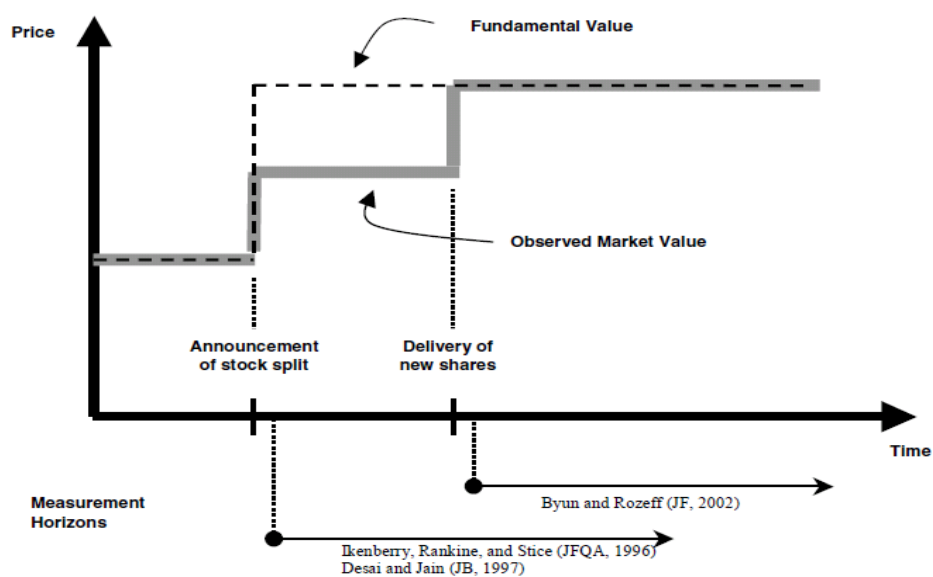


Figure.1 Copied from Rodney D. Boehme and Bartley R. Danielsen (2004)

the 1927-1996 time period, when they form equally weighted portfolios of splitting stocks. The reported mean excess return of 3.74% is considerably less than the values reported in IRS (1996) and Desai and Jain (1997) that are in the 7% to 8% range. An unpublished study by Boehme and Danielsen (2004) attribute this difference to the different measurement horizons used in these studies (post-announcement vs. post ex-split). I find this assessment to be partially correct. The fact that Byun and Rozeff (2003) use a much longer time horizon should also be a contributor to this difference, as their sample covers periods where splits have different long term effects than the 1975-1990 and 1976-1991 periods studied in IRS (1996) and Desai and Jain (1997). In fact

Byun and Rozeff (2003) show that the only period in history where all >25% stock splits are followed by statistically significant excess returns, when the excess returns are calculated on

	2-1 Splits			Splits ≥ 0.25		
	<i>N</i>	BHAR(%) (<i>p</i> -value)	CAR(%) (<i>p</i> -value)	<i>N</i>	BHAR(%) (<i>p</i> -value)	CAR(%) (<i>p</i> -value)
1927 to 1959						
(1) EQ	166	2.97 (0.063)	2.51 (0.072)	811	1.36 (0.065)	1.35 (0.048)
(2) VW	165	1.37 (0.246)	1.63 (0.221)	811	2.16 (0.075)	1.38 (0.167)
1960 to 1974						
(3) EQ	778	1.87 (0.060)	2.22 (0.024)	1,642	0.00 (0.273)	0.00 (0.204)
(4) VW	778	0.00 (0.465)	0.43 (0.379)	1,642	-0.43 (0.571)	-0.27 (0.542)
1975 to 1990						
(5) EQ	1,802	4.32 (0.000)	3.67 (0.000)	4,454	3.03 (0.000)	2.29 (0.000)
(6) VW	1,802	3.63 (0.003)	3.06 (0.007)	4,454	1.57 (0.157)	1.08 (0.208)
1991 to 1996						
(7) EQ	815	4.39 (0.002)	3.22 (0.005)	1,870	3.97 (0.001)	2.77 (0.003)
(8) VW	815	-0.17 (0.289)	0.35 (0.227)	1,870	0.42 (0.176)	0.75 (0.139)

Table.1 Copied from Table III of Rodney Byun and Rozeff (2003)

both an equally and value weighted basis, is the 1975 to 1990 time period. Nevertheless, I think it is important that Byun and Rozeff (2003) also find meaningful CAR excess returns when portfolios of 2-for-1 splitting stocks are created on an equally-weighted basis for the time period 1960 to 1996 (at a 5% significance level per bootstrapping) and 1927 to 1996 (at a 10% significance level per bootstrapping). This indicates that large splits are associated with good news in all time-periods.

Byun and Rozeff (2003) also apply a second methodology in addition to the Buy and Hold Abnormal Return methodology. They test post-split long-run performance using the technique of calendar-time abnormal returns developed by Mitchell and Stafford (2000). For each month

from 1927 to 1996 they create portfolios of stocks that have experienced splits in any month in the previous 12 months. Then, for each firm in the portfolio at time t the Carhart 4-factor model (Fama-French 3-factor model) is estimated over a 49-month period centered on that month:

$$R_{it} - R_{ft} = \alpha_i + \beta_i(R_{mt} - R_{ft}) + S_i * SMB_t + H_i * HML_t + M_i PR1YR_t + \varepsilon_{it} \quad (3)$$

(for $i=1$ to N , where N is the number of available firms in the portfolio at t , $N \geq 10$; for $t=1$ to 49)

Each month, individual firm loadings are averaged to calculate an updated monthly portfolio factor loading. Using these updated portfolio loadings every month one can calculate the expected portfolio returns as the following:

$$E[R_{pt}] = (\alpha_p + R_{ft}) + \beta_p(R_{mt} - R_{ft}) + S_p * SMB_t + H_p * HML_t + M_p PR1YR_t + \varepsilon_{it} \quad (4)$$

($\alpha_p = \text{average}(\alpha_i)$, $\beta_p = \text{average}(\beta_i)$, $S_p = \text{average}(S_i)$, $H_p = \text{average}(H_i)$ for $i=1$ to N)

Then, Calendar Time Abnormal Return (CTAR) for each month is calculated as the difference between the realized return of that month's portfolio minus the expected portfolio return as calculated in equation (4). Therefore $CTAR_t$ is:

$$CTAR_t = R_{pt} - E[R_{pt}] \quad (5)$$

For the 3-factor Fama-French CTAR model, Byun and Rozeff (2003) find that over the entire period, the equal-weighted method for either 2-1 splits or all splits produces significant abnormal returns in two-tailed tests with relatively small abnormal returns, 1.68 and 1.21 percent, respectively. For the 4-factor Carhart model Byun and Rozeff (2003) find that equal-weighted abnormal returns average 0.60 percent between 1927 and 1996 in the 2-1 sample with similar results for the all split (split factor $>25\%$) sample. Value-weighted abnormal returns range between 0.84 percent for the 2-1 sample and 0.48 percent for the all-split sample. All these results are statistically insignificant. Thus, long-run abnormal returns following splits found using the Fama-French (1993) model disappear with the Carhart model. The authors find

significant excess returns in the 1975 to 1990 period using the Carhart model, except for the equal-weighted sample of all splits. In each sub period, Carhart-model average abnormal returns decline slightly, compared to Fama-French model returns. The authors conclude that the decrease in estimated returns indicate that momentum may be a positive factor influencing post-split returns of stocks that split.

After analyzing these studies I have concluded that the 1975-1990 (1991) period is an exceptional period. Only in this period long-run excess returns following splits are robust to different statistical analysis techniques. It is also only in this period that the pre-split run up does not carry over to the post-split era, thus the lack of momentum effect in the 1975-1990 era is explained. Depending on the performance measure one can still conclude that 2-for-1 splits are followed by significant excess returns for most time periods. I do however consider the Calendar-time performance measure using the Carhart (1997) four-factor model to be more reliable than other measures utilized. My take from past research is that long-run excess returns following stock splits are not robust to all-time periods. Nevertheless it is clear that splitting firms do not under-perform non-splitting firms in the long-run when the performance comparison is undertaken subsequent to the month following the split ex-date.

I conclude that splits are preceded by strong long-run performance by splitting firms relative to their peers in the market in all time periods. Furthermore split announcement day and split-ex day as well as days subsequent to these events result in excess abnormal returns for all sorts of splitting firms (categorized based on size, book-to-market, post-split price) in all time periods as well. There is further positive reaction to the split event in the year(s) following the split in the 1975-1990 period only and there are not any meaningful excess gains in the post split period for other time eras studied. However, it is certain that the gains of the announcement day, the split ex-day and the immediate days following these days are preserved in the 3 years subsequent to the split in all time periods for an average splitting firm. Thus I conclude that the short-run excess returns around split announcement and ex-split days are significant and these short-term excess returns are not negated in the long-run, at least for firms that are not in the smallest (1% 10%) post-split price percentile. In the 1975-1990 time period, lowly priced firms have positive short-run excess returns around the announcement day and the split ex-day yet these short-run

excess returns are negated in the subsequent year(s). Possible under-reaction to split announcement exists in the 1975-1990 period as stock splits in this time period are followed by long-run excess returns in addition to the short-run excess returns documented around the announcement and split-ex dates. There are not significant long-run returns in other periods. Studies have shown that in the 1975-1990 period small and low book-to-market firms have the largest short-run (-2 to +2 days around the announcement date, where announcement date is numbered 0) excess-returns in response to split announcements. It is not clear if this is so for the whole of 1927-2005 time period.

Section 2: Changes in Stock Return Volatilities subsequent to Ex-dates of Stock Splits

Earlier papers by Ohlson and Penman (1985), Dravid (1987), Dubofsky (1991), and Koski (1998) have documented a significant increase in return volatility of US-based equities following stock splits with split factors larger than 5-for-4. Furthermore Reboredo (2003) has documented similar results for 2-for-1 and larger stock splits that take place in the Spanish Stock Market, Bolsa de Madrid for the 1998-1999 time period. Ohlson and Penman show that the increase in return volatility is permanent as there is no fading in the volatility value one year following the split. This increase also is quite large and Ohlson and Penman find a mean increase of 30% in the standard deviation of returns. Some in the literature have related this huge increase in return volatility to measurement error. Blume and Stambaugh (1983), Gottlieb and Kalay (1985), and Amihud and Mendelson (1987) show that bid-ask spreads and price discreteness induce an upward bias in the estimated volatility of observed stock returns. Since such measurement biases increase at lower price levels, it has been suggested that the increase in return volatility around splits may be due to measurement error. In response to this possibility Koski (1998) shows that almost none of the observed increase in realized volatility is due bid-ask spreads or price discreteness. Furthermore, in their recent paper Julio and Deng (2006) show a clear response to stock split announcements in the options market and provide additional evidence that changes in volatility around the split ex-date are real and not due to error in the measurement procedure. In this section I will discuss these empirical results and I will explain the measurement techniques used carefully.

2.1 Standard Method of Measuring Realized Volatility Increases Around Split Ex-Dates:

In order to test for changes in volatility subsequent to a split most studies use a non-parametric test proposed by Ohlson and Penman (1985). Dravid (1987), Dubofsky (1991), Koski (1998), Reboredo (2003) all use the same methodology and thus I believe it is important that I explain this technique. The binomial proportionality statistic, P , where $P = \Pr(x_2 > x_1)$ is applied to test the hypothesis

$H_0 : P = 0.5$ (H), no change in return volatility post-split, when compared with pre-split

$H_1 : P \neq 0.5$ (A), there is change in return volatility post-split compared with pre-split,

where x_1 and x_2 denote pre and post split values for the variable of interest. x_1 and x_2 in this case denote **daily stock return volatility**. Since squared values of expected daily returns ($E^2[r]$) are about $1/1000^{\text{th}}$ of expected squared daily returns ($E[r^2]$), Ohlson and Penman approximate for daily return volatilities with **expected squared daily returns**. As such, x_1 and x_2 simplify to **pre- and post-split values of $E[r^2]$** .

To control for day of the week effects on the variables of interest, Ohlson and Penman (1985) compare pre- and post-split squared daily returns by matching the squared return for the first trading day following the split declaration date with the squared return for the first same day of the week following the split date (for example Monday to Monday). This process is repeated for the second day, and so on until the day just prior to the split date for the whole time period between split announcement and split ex-date. The number of comparisons for each split is equivalent to the number of trading days between the declaration and split dates. Assuming independence across N observations (for $i=1$ to the last split event, $N = \sum \text{number of trading days between the declaration date}_i \text{ and split date}_i$), the binomial statistic $z = 2*(P-0.5)*\sqrt{N}$ is distributed asymptotically as a standard normal. With this assumption in place the value of the binomial z -statistic is used for statistical significance. Because Ohlson and Penman assume that returns in period 1 (announcement to split) and in period 2 (equal time after split) are independent and normally distributed with mean zero, $Y = [r\text{-post}^2 / \sigma\text{-post}^2] / [r\text{-pre}^2 / \sigma\text{-pre}^2]$ follows an $F(1,1)$ distribution. This implies that: $\Pr\{ r\text{-post}^2 > r\text{-pre}^2 \} = \Pr\{ Y > \sigma\text{-pre}^2 / \sigma\text{-}$

post²}. Prob.=Pr{ r-post² > r-pre² } is calculated by comparing the observed squared daily returns with the matching technique described. Then it is easy to verify that:

$$F_{(1,1)}^{-1}(1-\text{Prob}) = \sigma\text{-post}^2 / \sigma\text{-pre}^2.$$

With this result one can calculate the change in stock return volatility subsequent to the split as:

$$\text{Percent Change in Volatility} = (\sigma\text{-post} - \sigma\text{-pre}) / \sigma\text{-pre} = \sqrt{[F_{(1,1)}^{-1}(1-\text{Prob})]} - 1 \quad (6)$$

It is also possible to calculate the sub-period return volatilities for the announcement-to-split ex-date (K days) and split ex-date to split-ex-date+Kth day periods but due to Jensen's inequality the estimates of percentage increase in volatility are most likely biased upwards. Thus, it seems there is consensus in the literature in favor of comparing squared daily returns in the pre-split period with squared daily returns in the post-split period via non-parametric tests as long as the comparison takes into account the day of the week effects. Table 2 summarizes these studies.

<u>Study</u>	<u>Exchange</u>	<u>Time-Period</u>	<u>Number of Splits</u>	<u>Percent Change in Volatility</u>⁴
Ohlson-Penman(1985)	NYSE	1962-1981	1257 (forward splits)	+ 27.7%
Dravid (1987)	NYSE	1962-1981	57 (reverse splits)	- 59.3%
Dubofsky (1991)	NYSE/AMEX	1962-1987	1082/558 (forward splits)	+24%, +14.9%
Koski (1998)	NYSE	1987-1989	361 (forward splits)	+20%
Reboredo (2003)	Madrid	1998-1999	57 (forward splits)	+21.1%

Table.2 Summary of Papers that use the Ohlson-Penman Methodology

To account for measurement errors Ohlson and Penman (1985), Conroy, Harris and Benet (1990), Dubofsky (1991), and Koski (1998) also examine weekly return variances. They all find

⁴ Backed from Equation (6) using the normality assumptions

slightly smaller increases in volatility post-splits, when measured via weekly returns. Nevertheless the volatility increases are still significant on a percentage basis and they are all statistically meaningful. Furthermore past researchers also show that these volatility changes hold for the year subsequent to the split ex-date which shows that the change in volatility is far from being temporary. Figure 2 shows this lasting effect.

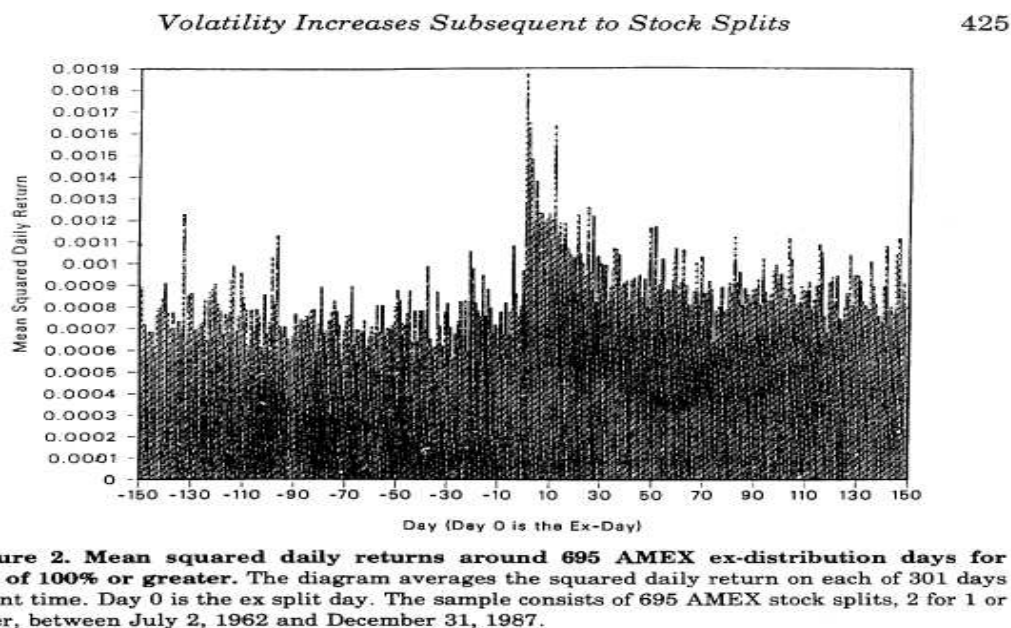


Figure.2 Copied from Dubofsky (1991)

2.2 Intra-Daily Estimation of Realized Volatility Increases Around Split Ex-Dates:

Squared daily returns have quite often been used as a measure of volatility. However, Anderson and Bollerslev (1998) demonstrate that the incorporation of high-frequency data vastly improves ex-post volatility measurements. Poteshman (2000) shows that almost half of the forecasting bias in the S&P 500 index (SPX) options market is eliminated if one estimates realized volatility using intraday observations on SPX futures, that are sampled every five minutes, rather than using daily close values. Julio and Deng (2006) use NYSE TAQ database and observe prices for splitting stocks every 5-minutes in the 1996-2003 time period. They define ph,t to be the natural logarithm of the stock price at time h on date t , where $h=1, \dots, H$ and $t=1, \dots, T$. H represents the

number of intra-daily observations used per day and T is the number of days in the sampling period. They calculate a series of intra-day log returns $rh,t = ph,t - ph-1,t$ and then using the squared values of these intra-day log returns they find an unbiased estimator of the population return variance $\sigma_t^2 : s_t^2$, where s_t^2 is as follows:

$$s_t^2 = \frac{1}{H} \sum_{h=1}^H r_{h,t}^2.$$

With this methodology Julio and Deng (2006) calculate 2 average intra-day return volatilities for each split event: One for the 20 days preceding the split ex-date and the other for the 20 days subsequent to the split ex-date. On average for all split events they find a statistically meaningful 32.83% increase in realized volatility around the ex-date. This value is similar in magnitude to the changes reported by earlier studies.

2.3 Implied Volatility Changes around Stock Split Announcements:

One way to make sure that the volatility changes around stock splits are real is to look at the effects of split announcements on the derivatives market. There have been three major studies so far that investigate whether stock return volatility changes subsequent to stock splits are factored in option pricing. The first two of these studies are by Sheikh (1989) and Klein and Peterson (1988). Sheikh studies 83 options and splits from December 1976 to December 1983 and Klein and Peterson study 96 stock splits and options from January 1978 to December 1984. These studies find no changes in the implied volatilities of splitting stocks compared to control firms on the split announcement date. One possible explanation why ex-split volatility increases are not incorporated in the options market for this time period comes from Julio and Deng (2006): “There are studies that claim a regime shift occurred in the options market in 1987. These studies argue that implied volatility is more biased prior to the October 1987 crash. They attribute the shift to learning by market participants and improved option market efficiency following the crash.”

Using implied volatility estimates from the Option Metrics Ivy database⁵ Julio and Deng (2006) find that:

- Around the split announcement, the implied volatility of options expiring after the split ex-date increase significantly relative to that of options expiring prior to the ex-date
- Implied volatilities of options expiring after the split ex-date increase gradually from the announcement date to the ex-date and level off thereafter
- Implied volatilities of options expiring after the split announcement date but before the split ex-date increase temporarily around the announcement date, then drop quickly to its pre-announcement level.

These results are what standard option pricing theory would have predicted indicating that implied volatility, as it relates to stock splits, reflects market participants' expectations about future realized volatility. Furthermore Julio and Deng find that changes in implied volatility vary positively with the size of the actual future increase in the realized volatility of the underlying stock. Even though these forecasts are biased and inefficient, they nevertheless provide informative forecasts of actual changes in realized volatility at the ex-date. The strong reaction in the options market further confirms that the measured increase in realized volatility is real and not due to measurement error.

2.4 Firm Characteristics and Realized Volatility Changes around Stock Split Ex-Dates:

Julio and Deng (2006) incorporate firm characteristics from the COMPUSTAT database into their split dataset. They report that small splits (factors less than 50%) experience no significant increase in realized volatility at the ex-date, while volatility increases for medium-sized splits (with factors between 50% and 200%) are the largest and significant. For very large splits (split

⁵Option Metrics Ivy database implied volatility estimates are calculated using a pricing algorithm based on the Cox-Ross-Rubinstein (1979) binomial tree model, adjusted for dividends. The implied volatility is computed by iteratively running the pricing model with different values of volatility until the price of the option converges to the midpoint of the option's best closing bid and best closing offer prices

factor greater than 200%), the change in volatility is still significant but not as large as for the medium-sized splits. Koski (1998) doesn't find significant differences in the volatility changes of small (25% to 100% split factor) and large (split factor greater than 100%) splits. Ohlson and Penman (1985) do not analyze small splits. Dravid (1987) also finds qualitatively similar results to Julio and Deng (2006) in the time period he studies (1962 to 1981) as in his sample smaller splits (split factor <100%) experience relatively much smaller volatility increases when compared to larger splits (split factor >100%) .

Julio and Deng (2006) also show that the average change in realized volatility around the split ex-date decreases monotonically with firm size. They report that the average change in realized volatility is 18% for the smallest firms, compared with 8.7% for the largest firms. The authors find no relationship between the pre-split book-to-market value of a splitting firm and the change in the realized volatility subsequent to the split.

2.5 1996-2005 Splits:

I have conducted an analysis of stock splits in the 1995-2005 period. Julio and Deng (2006) study splits in the 1996-2003 time period for stocks that have options. I include splitting stocks that do not have options as well. Using the CRSP database I find a total of 5464 stock-splits of all sizes, including reverse splits, in this period (distribution code 5523). Of these splits I eliminate 1178 of them that have a cash-dividend distribution within +/- 30 days of a stock-split event. This is an attempt to find "pure" splits. I further eliminate splits with a split factor less than +25% from my sample and end up with a total of 3224 pure forward-splits. Again using the CRSP database I match squared daily returns for the 15 days preceding and 15 days subsequent to each split event as defined in Ohlson and Penman (1985). I compare squared daily returns for the +Nth day vs. the -Nth day, for N=1 to 15, for each split event. My overall sample size includes 48360 comparisons of pre and post split squared daily returns. I find that for 55.45% of these comparisons squared daily returns are larger in the post-split era. Following Ohlson-Penman (1985) non-parametric analysis this value amounts to an average volatility increase of 18.77% following the split. I conclude from past research as well as from my own analysis that

post-split volatility increases are real, robust to measurement technique, measurement period, and the era studied.

Section 3: Reasons for Stock-Splits

In Sections 1 and 2, I have established how the long-run and short-run equity returns and return volatilities change subsequent to split-announcements and split ex-dates. I have shown that splitting firms experience unusual growth preceding their split decisions and that split announcement date and split ex-date are followed by excess returns that are not negated in the long-run. I have summarized the research that undoubtedly shows that realized return volatility increases subsequent to a split and stays at this higher level in the year subsequent to the split. I verify this result for the 1996 to 2005 time period.

In Section 3, I will present the various theories that have been put forward as explanations of why companies decide to undertake stock-splits. Although the results of the first two sections are not the only parameters of concern regarding a stock-split, it is clear to me that any theory, hoping to explain why split decisions are undertaken, should not conflict with the empirical results of Sections 1 and 2. I use the results of Section 1 and 2, in conjunction with other empirical measurements, as my sanity check parameters when evaluating the theories I discuss in Section 3.

Actors Affected by Stock Split Decisions:

A stock-split decision concerns four major parties. These are the following:

- The Board of Directors (in some cases the management team) of the splitting firm (decision-maker, possible beneficiary)
- Market makers (possible beneficiary and the intermediary between the management and prospective shareholders)
- Existing shareholders of the splitting firm (pre-split)
- Prospective shareholders of the splitting firm (post-split or post-announcement)

Current literature has studied the reasons for splits, to a large extent, from the perspectives of management teams (board of directors) and market makers. This is understandably so as shareholder approval for stock-split decisions is generally not needed because a stock-split is considered as a stock dividend and in most cases the number of shares outstanding after the split is still below the maximum number of shares authorized by the splitting company's shareholders. Almost always only board of directors' approval is necessary and enough. Thus, most theories trying to explain the reasons-for-splits are management centric and most of these theories also look for reasons to explain how market-makers would benefit from split decisions. Yet, studies documenting the changes in clientele structures following splits suggest that one should consider existing (pre-split) and prospective (post-split) shareholders as meaningful actors of any theory hoping to explain why companies split their stocks. In addition to using the results of Section 1 and Section 2 as my sanity checks, I will also try to make sure that any theory offered as a reason for stock splits does not violate the objection functions of these four actors that affect and are affected by stock-split decisions.

Theories for Stock Splits:

In the letter dated June 9, 2006⁶, Terri L. Turner, Corporate Secretary for Marriot International, Inc. tells the existing shareholders of her company why the Board of Directors has decided to undertake a 2-for-1 stock split with the following statement:

“It is my pleasure to inform you that on April 28, 2006, the Board of Directors of Marriot International, Inc. (“Marriott”) approved a two-for-one split of the company’s Class A common stock in the form of a stock dividend. The stock split was declared in recognition of our strong *confidence in our company’s* strength, competitive position, and *growth prospects*. We also believe that the split will make a share of Marriott common stock *more affordable* to a *broad range of potential investors* and *increase liquidity* in the trading of Marriott shares.”

⁶ Taken from the letter dated June 9, 2006 from the Management of Marriot International, Inc. to shareholders of Marriot International, Inc. The letter is informing the shareholders about the 2-for-1 stock split decision undertaken by the Board of Directors on April 28, 2006, with an effective split ex-date of June 12, 2006
<http://www.shareholder.com/mar/downloads/letterto shareholders.pdf>

Surveys, such as the one by Baker and Phillips (1995), show that managers justify splits on the basis that they improve liquidity and marketability. Every year, on average there are one-hundred-and-ten 2-for-1 or larger stock-split events taking place and most board of directors mention similar reasons as to why they have decided to split their stock. Finance literature has tested these and other possible explanations. The following are the major theories that have been offered as possible reasons-for-splits:

3.1 Signaling Theory:

Fama et al. (1969) theorize that management decides to undertake a split if it believes that the future dividends of the company will be higher. First formalization of the signaling theory, however, has been put forward by Grinblatt, Masulis, and Titman (1984) (GMT) as a possible explanation of the excess returns observed around split announcement and split-ex dates. GMT (1984) hypothesize that a management team with preference for a specific price range for its stock may choose the timing of a stock split in order to reveal private managerial information regarding future stock-returns. GMT (1984) dismiss their own theory, however, on the grounds that a split can be costlessly reproduced by a firm, with no price-range concerns (or other concerns regarding a split decision, whatever they may be for that matter) that would merit a genuine split decision, merely to raise its price in the short-run. Two sources of cost have been suggested that would make a signal credible.

Signaling Cost 1: Per-Share Based Commissions

Brennan and Copeland (1988) counter the GMT (1984) argument and theorize that splits credibly signal managerial information as they argue that transaction costs following splits increase. They develop a transactions cost model that assumes that the fixed cost element of brokerage commissions increases the per-share costs of lower priced stocks. Since stock splits result in lower-priced shares they result in higher brokerage costs for the pre-split shareholders and as such stock split decisions are not costless signals. Furthermore, as pointed out in Brennan and Hughes (1991) these higher brokerage commissions (mostly stemming from per-share fixed commissions) increase the overall revenue of the market makers. In return, market makers have

more motivation to publicize splitting-stocks compared to other stocks in the overall investment pool and as Merton (1987) points out since investors only invest in stocks they know about, increased brokerage fees are nothing but compensation to market makers for the information they produce and supply the public with. The cost is ultimately incurred by the existing shareholders including the managers of the firm. This is the main component of the signaling cost that the literature has proposed.

Signaling Cost 2: Relative Bid-Ask Spreads

Changes in bid ask spread for a stock, in relation to the trading value of the stock price, has been measured in several ways:

- *Relative Bid Ask Spread* = $[ask\ price(t) - bid\ price(t)] / [trade\ price(t)]$ used as in Copeland (1979), Conroy Harris Benet (1990)
- *Effective Spread* $(t) = 2 * |tradeprice(t) - 0.5 * (bidprice(t) + askprice(t))| / [tradeprice(t)]$ and
- *Relative Effective Spread* $(t) = Effective\ Spread / trade\ price(t)$ used as in Gray, Smith, Whaley (1996), Schultz (2000)

There are numerous studies which show that relative effective spreads increase subsequent to splits. Copeland (1979), Conroy Harris Benet (1990), Gray, Smith, Whaley (1996), Kryzanowski and Zhang (1996) and Schultz (2000) find that the relative and relative-effective bid-ask spreads increase subsequent to stock-splits. Even though the most recent paper by Lipson and Mortal (2005) shows that the increases in effective and relative effective bid-ask spreads following splits do not contribute to an increased promotion activity by market makers, this effect should still be considered as a positive contributor to the cost of signaling due to increased trading costs.

Information Content of the Stock-Split Signal:

Further strengthening the signaling theory are the findings of McNichols and Dravid (1990) that the size of the split is positively correlated with the excess returns around the split announcement day. This finding indicates that managers transmit private information about their knowledge of future earnings via the split factor. McNichols and Dravid (1990) also show that split factors

increase in pre-split share and decrease in pre-split value of market equity indicating that firms split their stocks when their share prices increase beyond a preferred level and that larger firms prefer their shares to be traded at higher prices compared to firms with low market values.

Split Announcement Used in Conjunction with Dividend Signals:

Desai and Jain (1997) look at the long term and short term effects of a split announcement when there is a concurrent dividend increase announcement (if the splitting firm pays dividends) or when there is a dividend initiation announcement (if the splitting firm normally does not pay dividends). They find that both the short-term and long-run excess returns, when there is an additional dividend related signal are higher. Nevertheless, “pure” stock-split announcements continue to produce excess returns in amounts similar to those reported in GMT (1984). The finding that dividend increase and stock split announcements are used in conjunction may make it possible to integrate split-announcement events into signaling theories that model stock-dividend events.

Does the Market get it? Changes in Information Asymmetry Post Stock-Splits:

Since there can be information asymmetries in the market, managers might use financial decisions such as stock splits to convey favorable private information to investors about the future performance of the firm to reduce such market inefficiencies. At least this is one of the basic assumptions of most signaling theories. Increased analyst coverage subsequent to stock-splits, due to higher profits and thus more promotional activities by market makers, has been documented by Brennan and Hughes (1991). This result has been used as proof that stock splits help to reduce information asymmetries between informed and uninformed traders in the market. However Desai et al. (1998), using the methodology developed by George, Kaul, Nimalendran (1991)⁷ to extract the adverse information component from the total bid-ask spread, find that

⁷ George, Kaul, Nimalendran (1991) Model: This model divides bid-ask spread into only two pieces: order-processing costs that estimate the costs of market maker for providing liquidity and adverse-selection costs representing the profits that the market maker earns from uninformed traders in order to compensate the market maker for possible losses due to trades with informed traders. It is a variant of the Stoll (1989) model

both the relative spread as well as the adverse information component of the spread increase following splits. When it comes to dividing the bid-ask spread into its components, I believe Gray, Smith, Whaley (1996) model is easier to implement and more informative than Stoll (1989) or George, Kaul, Nimalendran (1991). Gray, Smith, Whaley (1996) hypothesize that the market maker's effective bid/ask spread is a function of order processing costs, inventory holding costs and the degree of competition. They use the inverse of trading volume of the stock to proxy for order processing costs, stock price volatility to measure inventory holding costs and one minus the ratio of trading volume on the primary exchange where the stock is traded (for example NYSE) to total trading volume across all exchanges where the stock is traded (for example NYSE+AMEX) to proxy for competition⁸. They run a cross-sectional regression model to estimate the change in the relative effective spread of the market maker using the proxies for order processing costs, inventory holding costs and the degree of competition. Gray, Smith, Whaley (1996) find that order processing costs and inventory holding costs increase while the degree of market competition decreases subsequent to a stock-split. Furthermore Desai et al. (1998) find that both the transient, as well as the permanent components of volatility increase subsequent to a stock split, meaning that uninformed and informed trading levels both rise after the stock split.

Increased adverse selection problems, decreased liquidity and decreased market competition indicate to me that information asymmetries are not necessarily reduced in the market subsequent to a stock-split. Nevertheless, I do believe the signaling theory has a lot of power since:

- It is possible to show that stock split decisions are indeed costly to splitting firms
- It is clear that stock split announcements and stock split ex-dates are followed by short-run excess returns that are not negated in the long run as can be seen from the results of Section 1

⁸ Gray et al. also use the total number of market makers as a proxy for the intensity of competition in related regressions

3.2 Optimal Price / Optimal Trading Range Theory:

Another possible explanation that has been offered stems from empirical observations that show that companies try to keep the value of their stock within some “optimal” range. An interesting observation regarding this issue comes from Angel (1997) who shows that the average share price on the NYSE has stayed at about the exact same dollar figure (\$30) between 1943 and 1994 while in the same time frame the S&P 500 gained 1500% and the consumer price index rose 500%. It has been suggested that this “optimal” range provides for greater liquidity as well as allowing for achieving dispersion in management⁹. Whatever the underlying reason for an optimal share price, the strongest evidence in support of this theory comes from Conroy and Harris (1999). Conroy and Harris (1999) show that a firm's past history of stock splits plays a crucial role in both the design and effect of current splits. First, they show that the price to which a stock splits can be explained by the stock price level after a firm's last split. Second they use past split information along with firm characteristics to estimate an expected split factor for a company. They find that abnormal returns to shareholders around stock split announcement and ex-split days are significantly higher when management announces a larger-than-anticipated split factor. Furthermore Conroy and Harris (1999) also find that analysts increase earnings forecasts significantly when managers announce a split factor larger than anticipated. Unlike share returns, which may be driven by both information and transactions-cost factors, earnings forecasts are direct predictions of corporate performance. Other than indicating that firms do indeed have “optimal price” ranges they prefer to have their stock traded within, Conroy and Harris (1999) is

⁹ Further anecdotal evidence comes from the following authors:

"The purpose (of splits), apparently, is to bring the market price of the split stock down to the desired range--in the nineteen forties and fifties, \$15 to \$40 a share." -- Arthur Stone Dewing (1953) in the leading finance text of the day

"Managers report that the main motive for issuing stock splits is to move the stock price into a better trading range...the preferred trading range for these managers is from \$20 to \$35." -- Baker, Phillips. and Powell (1995) in a review article on splits

also consistent with signaling models. Their finding gives credence to the notion that split factor is indeed the signal itself, and a larger than anticipated split factor signals even higher excess returns around split announcement and split-ex dates than normally anticipated. This theory has a lot of merit when analyzed in the signaling context as shown by Conroy and Harris (1999). I conclude that “Optimal price/trading range” theory does not have any value as a stand alone explanation of stock splits yet it is an important part of the overall signaling theory.

3.3 Self Serving Management and Dispersion of Control Theory / Enlarged Clientele:

A possible explanation for stock splits claims that a self-serving management prefers a diffused ownership since small investors can not exercise much control over the company and a stock split would likely achieve this. However studies done by Maloney-Mulherin (1992) and Powell-Baker (1993-1994) show that management dispersion hypothesis does not hold. On the contrary their results show that stock splits accompany increases in institutional ownership for firms. Maloney-Mulherin (1992) and Powell-Baker (1993-1994) find that both the number of institutions owning shares and the percentage of shares owned by institutions increase subsequent to stock splits. Furthermore they show that for a control group of non-splitting firms, changes in these institutional ownership variables are not statistically significant and that the numbers of shareholders for both the splitting and non-splitting firms do not change significantly around the split. In a recent paper Lipson and Mortal (2005) find that the number of shareholders as well as the number of institutions increase subsequent to a split. They do not document an increase in the total institutional ownership. Schultz (2000) shows that the number of small buy orders increases sharply at the announcement of splits, which is supported also by Lipson and Mortal (2005). It seems that the shareholder base of a company subsequent to a split expands, yet the theory of a self-serving management that aims to reduce overall institutional ownership does not hold as the empirical results disprove this theory. Evidence against this theory is too strong. I conclude that management reaches the goal of a “more diversified” clientele, yet this does not mean that the splitting firm ends up with a more diffused shareholder base.

3.4 Tax-option Theory:

In Section 2, I document that realized stock return volatility increases after stock splits. A security with a price that fluctuates widely gives the opportunity to its holder to realize short-term losses that can be compensated with long term gains. For such securities the tax-option value of the stock increases as the expected cost of short-term capital gains tax decreases. Lamoureux and Poon (1987) argue that managers can perform a split to enhance the tax-option value of their shares. According to this theory during periods when long-term and short-term capital gains taxes are the same there should be no abnormal returns around split announcement or split-ex dates since Lamoureux and Poon (1987) claim that the market attaches a positive return to the stock split because of its tax option value. In other words as the US tax code changes excess returns around the split announcement and split-ex dates should also change. However a test of this hypothesis around the 1986 Tax Reform Act, which eliminated the distinction between long term and short term capital gains taxes, by Dhatt, Kim, Mukherji (1997) shows that market impact of stock splits does not disappear following tax code changes. Further evidence can be observed in all the documented excess return results from post-1986 in Section 1 of this paper. Evidence against this theory is too strong.

3.5 Optimal Relative Tick Size Theory:

One of the most closely studied theories is the so-called optimal relative tick size theory. For example Angel (1997) argues that the main motivation for splits is to keep the relative tick size (minimum tick allowed by the exchange/share price) within a certain range. This theory has its theoretical and empirical foundations in the Harris (1994) paper. Accordingly, the optimal relative tick size is not zero so that:

1. Traders' information sets are simplified and as such bargaining time is reduced and costly errors are prevented
2. Non-zero tick puts a floor on the bid-ask spread ($>$ minimum tick) thus makes sure dealers have enough incentives to make markets and promote splitting stocks
3. A "binding" relative tick size is needed to attract the desired clientele

4. Non zero tick enforces time and price priority in a limit order book thus ensuring continued liquidity

The 1st reason is proven valid by Schultz (2000). Schultz (2000) uses the TAQ database. TAQ's records contain the time, price and number of shares for each transaction. Furthermore each trade includes a code for cancellation, correction, or a change of sequence. Schultz (2000) tracks trades that are canceled due to error, corrected trades, and trades canceled not because of an error. When the percentage errors for splitting stocks are compared in the one-year preceding the split announcement with the percentage errors in the one-year period subsequent to the split-ex date there is a small (0.16%) yet statistically significant decrease in trading errors. Although statistically valid reducing errors does not seem to be a major driver for stock-splits.

The 2nd explanation has a long series of proponents: Copeland (1979), Conroy Harris Benet (1990), Gray, Smith, Whaley (1996), Kryzanowski and Zhang (1996), Desai et al. (1998) and Schultz (2000) all have shown that the relative and relative-effective bid-ask spreads increase subsequent to stock-splits. It is also organically related to the 3rd explanation which claims relative tick size helps a firm attract a desired clientele.

In relation to points 2 and 3, Schultz (2000) analyzes 235 stock splits between April 1993 and March 1994 and observes intraday trades and quotes. He finds that subsequent to the split there are 6400 daily net small buy orders (100-share orders are small orders) for his 235 stocks meaning that about 28 new small shareholders per day are added to the shareholder base of a splitting stock. Schultz (2000) also corroborates previous research that total shareholder base increases across all splitting stocks, in his sample by about 20%. Schultz (2000) concludes that the main reason for this increase in the shareholder base is due to brokers more heavily promoting the stock agreeing with Angel (1997). He suggests that not only spread related commission shares but also per-share based commission revenues to brokers could motivate this activity. However Lipson and Mortal (2005) have cast a lot of doubt on the validities of the 2nd and more importantly 3rd explanations. Lipson and Mortal (2005) ask a very intelligent and testable question: If relative tick sizes are so important, then should not we see changes in split activity as well as in clientele structure and liquidity as tick size changes in a given exchange?

This question is valid and indeed testable as NYSE changed its tick size first from \$ $1/8^{\text{th}}$ to \$ $1/16^{\text{th}}$ and then to just 1 cent over the last 20 years.

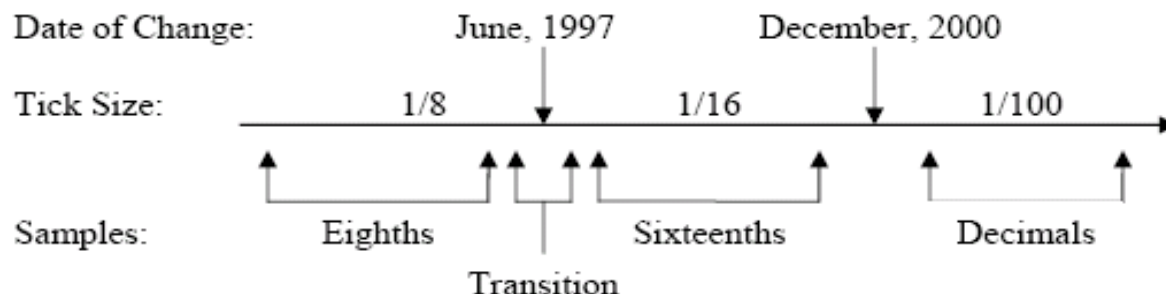


Figure 3. Evolution of tick sizes. (Figure copied from Lipson and Mortal December 2005, SSRN)

Lipson and Mortal (2005) partition the split-time-space into four samples. Three of the samples correspond to the periods when stocks traded in eighths, sixteenths, and decimals. They also examine the sample of splits around the time the NYSE moved from eighths to sixteenths. They call this fourth sample the transition sample. This transition period is unique because a two for one stock split would have the exact same relative tick size before and after the tick size change. Since a majority of splits are 2-for-1 splits this transition period gives the researchers a golden opportunity to compare how relative tick size affects splits. They compute the log change in clientele measures (such as Share Volume, Number of Trades, Trade Size, Number of Shareholders, Imbalance in Small Trades, Number of Institutional Owners and Number of Analysts Covering the Stocks) by running cross-sectional OLS regressions on the log values of the Market Value of the Firm, Stock Price, and Return Variance, for each of their four time periods. They adjust for time-trends by using control groups and use indicators to differentiate for the different tick-regimes. They find large differences in magnitude of the realized spread change between the binding tick size samples (eighths and sixteenths) and the decimals samples. However, they find no differences across any tick-regime samples in changes of trade size, number of shareholders and number of institutional owners. I think this study is extremely important as it shows that post split prices did not decline even though tick sizes were reduced from 12.50 pennies to 6.25 pennies at one point, and from 6.25 pennies to a single penny at

another point. In addition, the paper clearly shows that changes in tick-size do not have any effect on splitting activity. These results suggest tick sizes are not relevant when firms set trading ranges. Not only are tick sizes not relevant on post-split prices and trading activity, but the authors also find that changes in clientele measures are comparable in most instances across all tick regimes. This suggests that tick size effects are not necessary for splits to impact clientele. On the other hand, the authors find that gross revenues to market makers are affected by tick size, in line with previous research. This paper gives credence to the possibility that the changes in clientele after splits are due to per-share based commissions paid to brokers. Lipson and Mortal (2005) strongly disprove the theory that relative tick size is important in attracting a desired clientele and they also show that relative tick size has no effect on split decisions.

Proponents of the 4th explanation claim that the market is not concerned about high relative tick sizes itself, as the stock market has a long term upside trend, but that companies should correct for small relative ticks through splits. Angel (1997) claims that this correction is required as an optimal relative tick size helps to balance the benefits of increased liquidity against the higher costs paid by liquidity demanders. This optimal relative tick size argument suggests that optimized liquidity attracts more traders: individuals as well as institutions. Lipson and Mortal (2005) find no effects of tick size on the frequency or magnitude of splits. Furthermore, Lipson and Mortal (2005) find no significant differences in changes in adjusted-volume, number of trades and other possible proxies of liquidity measures. Thus the 4th explanation is also strongly challenged.

3.6 Increased Liquidity Theory:

Researchers have also proposed the idea that companies split their stock to achieve greater liquidity. The fundamental question in regards to this theory is whether splits increase or decrease liquidity, and if so how one should go about measuring liquidity around a stock split. There is also a related question: if liquidity decreases subsequent to splits, is the abnormal return achieved around the split event just a liquidity premium? Past literature has attempted to measure changes in liquidity around stock splits by analyzing the changes in three parameters: trading volume, relative effective bid-ask spread, and number of limit orders. I exclude the

measurement of liquidity via limit orders from this section as there is no direct study of the limit order book that documents the changes in liquidity.

Liquidity Measured via Trading Volume and Turnover:

One of the first papers to tackle the issue of why companies split is Copeland (1979). Copeland (1979) takes on Wall Street's version of the story that splits are needed to have a "wider" market. Splits, Wall Street insiders argue(d), increase the shareholder base of a company, leading to an increase in the trading volume of the stock and finally resulting in a reduction in bid-ask spreads. Such a reduction in the spreads means higher liquidity: a desirable outcome for the efficiency of capital markets. In order to test this hypothesis Copeland uses a Finite Time Series Model to measure the trading volume of individual securities. This model ties current trading to past and current information arrival and treats split events as new information for trading purposes.

The results are striking: Trading volume increases less than proportionately following splits. Copeland (1979) contains important results, however, he studies a very small sample size for his volume related observations (25). Lamoureux and Poon (1987) look at a much larger sample of 215 observations. They find results that support Copeland's research. Of the 215 splits they analyze, over 40% show a reduction in volume, adjusted for split factor and the general trading volume trends in the market, while only about 13% show an increase in adjusted volume.

Lakonishok and Lev (1987) consider monthly turnover as a measure of liquidity. They measure turnover as a percentage of traded shares over all outstanding shares and find that turnover significantly increases around split announcements by comparing average monthly turnovers of splitting stocks and a control group of non-splitting stocks. They determine that, for splitting stocks, monthly turnover monotonically increases between 8 months before the split announcement and the announcement date, then it reaches its peak during the announcement month (5.4% for splitting stocks vs. 4.1% for non splitting stocks) and starts reverting back to non-splitting stocks' levels 2 months after the announcement date. They agree with Copeland (1979) and Lamoureux and Poon (1987) that splitting stocks experience a decline in trading volume ,adjusted for general trading volume trends in the market and the specific stock split factor, after the announcement date. They do not see this as a sign of diminished liquidity or

reduced marketability. To support this view they point out to the strong price increase in splitting stocks in the year prior to the split announcement (+47%) and simply claim that the strong monotonic increase in the trading volume prior to the split announcement is due to the exceptional operational performance of splitting firms. Since the average monthly turnover for splitting firms is almost identical to that of those non-splitting firms as soon as two months after the ex-split date, they conclude that stock splits do not exert a permanent effect on volume of trade. This they conclude doesn't totally answer the question whether liquidity increases or decreases following a split but their results simply challenge the notion that trading volume around splits is a good measure of liquidity.

Further studies have confirmed that using trading volume as a proxy for liquidity is not a very good idea. Desai, Nimalendran and Venkataraman (1996) find that split and market adjusted volume increases following splits. These conflicting results regarding changes in trading volume subsequent to splits imply that the time frame analyzed is a factor in determining whether split-factor and market trends-adjusted volume increases, decreases, or stays flat following a stock split.

Liquidity Measured via Bid-Ask Spreads:

Copeland (1979) is the first to measure liquidity through the use of bid-ask spreads. He shows using 162 OTC firms from the 1968-1976 period that the average bid ask spread as a percentage of the bid price increased from 4.73% at 20 days before the split to 6.54% at 20 days after the split. Furthermore he runs simulations which show that revenues to brokerages increase at least by 7.1% after splits, another factor that indicates liquidity, in fact, is lower after a split.

A similar study is conducted by Conroy Harris Benet (1990) for 133 NYSE splits between January 1, 1981 and April 30, 1983. Conroy et al. find a significant increase in the relative bid/ask spread along with a significant reduction in the absolute level of the spread. Schultz (2000) furthers this study and finds that both the quoted as well as the effective relative spreads significantly increase in the post-split period with respect to the pre-split period. Kryzanowski and Zhang (1996) repeat these studies for splitting Canadian stocks and find that on the split ex-date, the mean bid-ask spread drops by 37.5 percent, while the mean relative bid-ask spread

increases by 45.7 percent. Furthermore they corroborate the previously done volume related studies and find that mean raw trading volume increases by 106 percent, while the mean trading value on a dollar basis decreases by 14.6 percent.

Gray, Smith, Whaley (1996) also corroborate earlier findings that the relative bid-ask spread increases after a split. They find that average relative quoted spread is 1.65% before the split and 2.15% afterward—a 29.7% increase. Gray, Smith, Whaley (1996) specifically try to understand what sub component of the spread changes due to the split. For this purpose they hypothesize that the market maker's effective bid/ask spread is a function of order processing costs, inventory holding costs and the degree of competition. The authors use the inverse of trading volume of the stock to proxy for order processing costs, stock price volatility to measure inventory holding costs and one minus the ratio of primary trading volume to consolidated trading volume to proxy for relative competition. Spread data come from the NYSE TAQ database. They also define the relative effective bid-ask spread as in similar fashion to the effective spread definition of 3.1. Accordingly they define relative spread as $RSPRD_i$:

$$\text{Effective Spread (t)} = 2 * |\text{tradeprice(t)} - 0.5 * (\text{bidprice(t)} + \text{askprice(t)})| / [\text{tradeprice(t)}] \quad (7)$$

They run OLS regressions to estimate the change in the effective spread and relative effective spread of the market maker:

$$SPRD_{id1,i} = \alpha_0 + \alpha_1.(1/TV_i)d1,i + \alpha_2.\sigma_{\Delta Si}.d1,i + \alpha_3.COMP_i + E_i \quad (8)$$

$$RSPRD_{id1,i} = \alpha_0 + \alpha_1.(1/\$TV_i)d1,i + \alpha_2.\sigma_{Ri}.d1,i + \alpha_3.(COMP_i / Si) + \alpha_4.(1 / Si) \quad (9)$$

They find that the effective spread as well as the relative effective spread both increase following a split. Furthermore they document that order processing costs and inventory holding costs increase while the degree of market competition decreases subsequent to a stock-split in both the effective spread and relative effective spread measures. Increasing order processing costs imply

that the costs that the market-maker has to incur to provide liquidity increase. Bid-ask spread based measurements indicate that liquidity decreases subsequent to stock splits.

Measurement of liquidity poses a serious problem. I know from Kaul, Jones and Lipson (1994) that as number of trades increases so does stock return volatility. Schultz (2000) shows that subsequent to a split number of small trades increases significantly. Furthermore Schultz (2000) also shows that the increase in the number of small trades is so significant that the number of overall trades also increases. This results in a realized return volatility increase. As volatility increases so do the inventory holding costs. It is also clear that either due to only per-share based commissions or due to the effect of both per-share based commissions and the increase in relative bid-ask spreads market maker's revenues subsequent to a split also increase. Furthermore both direct and indirect measures of degree of competition indicate that this variable decreases subsequent to a split. Thus I conclude that even if the real liquidity provision costs of the market maker do not increase, the perceived level of these costs surely increase, or if the real change in real liquidity provision costs is zero then the market makers are using the stock-split event to rip-off shareholders. I conclude that perceived liquidity in the market subsequent to a split does not increase and as such increasing liquidity can't be a valid explanation of why stock splits take place.

Section 4: Reasons for Return Volatility Increases Subsequent to Stock Splits:

In Section 2, I have shown how realized return volatility increases subsequent to stock splits. Furthermore, I have documented there are no measurement errors in this result, as the effects of the volatility jump are factored in the options market. It is also without a doubt that the change in volatility is not temporary as the change lasts for over a year. In Section 4, I will discuss theories that try to explain why stock return volatility increases subsequent to a stock split:

4.1 Microstructure Effects Drive the Increase in Volatilities:

Many researchers have suggested that the increase in measured return volatility is caused by microstructure effects. There are two major microstructure effects that have been discussed in the literature: price discreteness and bid-ask measurement effects. As shown in Section 3,

relative bid-ask spreads increase subsequent to splits and the changes in relative tick size have been suggested to motivate market makers promote splitting stocks more aggressively, albeit with less success. Recent papers seem to have disproved that the changes in relative tick size motivate market makers to promote splitting stocks more aggressively.

Gottlieb and Kalay (1985), and Amihud and Mendelson (1987) show that bid-ask spreads and price discreteness induce an upward bias in the estimated volatility of observed stock returns. It is also well known that the drop in price subsequent to splits increases relative bid-ask spread. Conroy, Harris and Benet (1990) relate this change in relative bid-ask spreads to volatility and show that increases in return variances are correlated with increases in relative bid-ask spreads. Dubofsky (1991) further claims that “measurement errors created by bid-ask spreads and the 1/8 effect, and also one or more of the elements that make the NYSE different from the AMEX, explain why the estimated volatility of daily stock returns increases after the ex-split date.”

Koski (1999) controls for these mentioned microstructure effects and still manages to show that the daily stock return variance increases at the split date. She controls for the possibility that return variances are partly caused by measurement errors by calculating “true” weekly variances for the pre and post split weeks, using bid-to-bid quotes instead of using transaction prices. This is in essence very similar to what Conroy Harris and Benet (1990) do with the exception of using bid-to-bid quotes. Furthermore Koski (1999) also calculates the change in the square of the percentage bid-ask spread from pre-split to post-split. She also calculates “observed” variances for the pre-split and post-split periods using transaction prices. Koski (1999) runs a simple OLS in the following form, where ΔTV_i denotes the change in true variance, ΔSi^2 denotes the change in the square of the percentage bid-ask spread and ΔOVi denotes the change in observed volatility, all calculated from the pre-split to post-split period on a weekly basis:

$$\Delta OVi = b_0 + b_1 * \Delta TV_i + b_2 * \Delta Si^2 + \epsilon_i \quad (10)$$

Koski (1999) reports that, for stock dividends and small splits, the increase in the observed variance is almost fully caused by the change in the true variance. Regression results indicate

that for large splits some of the observed volatility increase is eliminated when Koski (1999) uses bid-bid or ask-ask quotes instead of transaction prices. Nevertheless most of the observed volatility increase still comes from changes in the true variance. Weekly return variance comparisons during the post-split period vs. the pre-split period using bid-to-bid quotes instead of transaction prices produces almost an identical change. Observed volatility in all three cases, using bid-to-bid quotes, ask-to-ask quotes and transaction prices, increases from about 18% during pre-split period to 32% during post-split period. Koski (1999) also controls for price-discreteness, simply by sorting the split sample based on split-ex date price levels. She conducts Ohlson-Penman non-parametric tests and verifies that post split volatility increases at all price levels. Koski calculates that bid-ask errors contribute about 9% of the pre-split variance while they contribute about 12% of the post-split variance. This increase is much smaller than her control sample of non-splitting firms for which bid-ask errors contribute about 13% of the pre-split variance while they contribute about 18% of the post-split variance. Volatility changes for different ex-split day price levels in the pre-split and post split periods measured using bid-to-bid, ask-to-ask and bid-to-ask quotes are almost identical as well. Koski (1999) firmly shows that post-split volatility increases are robust to microstructure effects.

Further support proving that return volatility increases around stocks splits are real, and not caused by measurement errors, comes from options research. As explained in Section 2 earlier, Julio and Deng (2005) show that expected changes in real stock return volatilities on split ex dates are factored in option prices on split announcement dates. They prove this by analyzing the changes in the implied volatilities of options around split announcement dates. The data comes from Option Metrics Ivy database.

The theory that microstructure factors such as bid-ask spread and price discreteness drive the increase in realized return volatilities around split ex-dates is not valid.

4.2 Information vs. Changes in Trading Patterns:

“An important strand of research trying to explain what the root cause of volatility is suggests that informed trading is the cause of most volatility. French and Roll (1986) and Lockwood and Linn (1990) support this view, mainly because volatility during trading periods, when the

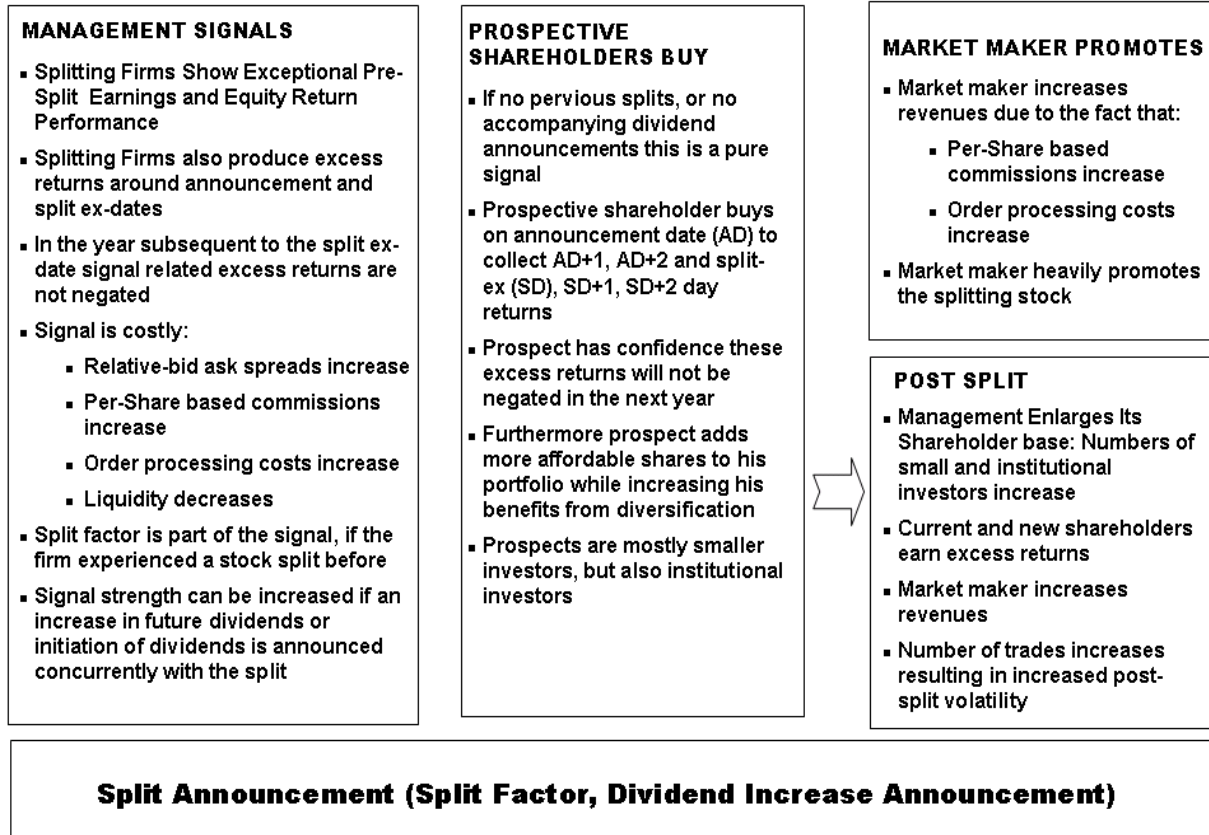
exchange is open, is much larger than during non-trading periods, when the exchange is shut. However, Jones, Kaul and Lipson (1994b) counter this by suggesting that it is in fact public information that drives volatility, because even if no trades take place on a day when a stock is available to trade, volatility is still much larger than the enforced non-trading period, and the information asymmetry component of the bid-ask spread is unchanged. Furthermore Lamoureux and Lastrapes (1990) and Brailsford (1996) show that GARCH effects present in the daily returns of individual stocks disappear when the contemporaneous number of trades is added to the conditional variance equation. Furthermore, Jones, Kaul and Lipson (1994a) examine whether daily number of trades or average trade size on a day better explains volatility. They find that the volatility is strongly influenced by the daily number of trades.¹⁰”

Supporting the Jones, Kaul and Lipson (1994a) theory, Koski (1999) shows that daily average of number of trades for splitting stocks increases from 64 to 75. Schultz (2000) lends support to this idea as he finds a large number of small trades following the split, most of which are buy orders, and that the total number of trades after the split increases. In the Schultz (2000) sample the average number of small trades per stock increases by about 28 following stock splits. Empirical evidence is in support of the Jones, Kaul and Lipson (1994a) theory. It is clear to me that increase in realized return volatility subsequent to the split event is caused by the increased number of trades, mostly stemming from the increase in the number of small trades.

¹⁰ This is heavily quoted from Walsh (1998)

Section 5: Stock Splits Explained:

STOCK SPLITS: THE STORY



In Sections 1 through 4, I have summarized the short-run and long-run effects of stock split announcements as well as what happens in the preceding and subsequent years around a stock split event. I have also summarized how firm characteristics influence the results. Furthermore, I have discussed the various theories regarding why splits occur and why stock return distributions change subsequent to split events. I have specifically focused on the changes in the first and second moments of stock returns and analyzed related theories such as optimal trading, optimal tick size, liquidity, and signaling. More importantly I have presented the pros and cons of each of these theories and concluded which of them I find more plausible. Wherever time permitted I replicated the empirical tests and verified the previous findings.

After analyzing all the evidence I have concluded that the following set of events can explain the causes and results of stock splits within a rational framework and in agreement with empirical measurements:

1. Signal: Management team of an exceptionally well performing company (in the recent 36 months or so) with private information regarding the future performance of their firm decides to split the company's shares.
 - a. This signal may be strengthened if it is accompanied with an announcement that declares futures dividends will be larger, or that the company, if it was not paying dividends up to that point, will initiate giving dividends
 - b. This signal may also be strengthened if the company went through a previous stock split event. The market would expect the company's stock to split to the post-split price level of the previous split event. If the split factor is bigger than this expected level future expected returns are even higher
 - c. The signal is costly to the firm. There are two cost components
 - i. Relative bid-ask spread increases due to the split and this results in higher order processing costs, which in turn reduces liquidity
 - ii. Pre-split shareholders incur higher aggregate costs resulting from per-share based commission costs
2. Promotion: As per-share based commissions and order processing costs will increase following the split market-maker has a lot to gain from increased trading. Market maker heavily promotes the stock to add new clientele.
3. Enlarged Clientele Base: With more coverage prospective shareholder buys the stock, based on the management team's signal and the market maker's information dissemination in order to reap the benefits of excess returns surrounding split announcement and split-ex dates. Prospect expects that these excess returns will not be negated in the year subsequent to the split ex-date. Furthermore prospect further diversifies his portfolio with non-negative long-run excess returns. Prospect can be a small investor or an institutional investor, but in most likelihood he is a small investor.

4. Increased Number of Trades: Company's shareholder base is enlarged, management has a more diversified clientele making their jobs more secure. Furthermore the management has solidified the gains of the exceptional returns period with this new clientele base. Shareholders earn excess returns around the announcement and ex-dates and keep their gains in the long-run. Market makers increase their revenues. At the same time as the number of small shareholders increases so does the number of small trades and aggregate number of trades. Due to the increase in number of trades stock return volatility also goes up around the stock-split event. As the split is costly, this signal has value over the year following the split thus the number of trades in the subsequent year doesn't decrease. Market maker's promotion efforts also help sustain the level of trading activity. Hence the increase in return volatility is not temporary and is sustained for over a year.

Future Research:

It is still open to debate whether the signaling costs discussed in this survey paper are large enough to give the split-signal enough credibility. I believe future research should focus on the specifics of the clientele changes following stock splits. Is splitting the stock a way for the management to attract less sophisticated investors after the firm has run the course of a strong period of growth? Would the composition of the shareholder base change in a way that the new clientele would be more exposed to behavioral biases such as the disposition effect? If so, how should the marketing activity around stock splits be regulated, if at all? How does the representative shareholder's holding period change after the split? Does the management care whether the shareholders are long-term focused or not? I believe a focus on how the characteristics of the clientele change after the stock split is the right direction for research.

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